A Chromophoric Dissolved Organic Matter (CDOM) Observatory

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LONG-TERM GOALS

The long-term goal of this project is to develop an understanding of coastal systems such that optical properties of complex coastal waters can be retrieved and predicted from remote sensing and modeling efforts.

OBJECTIVES

This project focuses on establishing a moderate-scale observatory (Neponset) to develop watershed and coastal ocean models and remote sensing algorithms and extending this knowledge to a larger system (Hudson).

Specific Objectives:

1.) Design and deploy CDOM observatory components in the Neponset Estuary and Boston Harbor.

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2.) Refine remote sensing algorithms for CDOM in the Neponset Estuary, Boston Harbor, and Massachusetts Bay based on high resolution and/or hyperspectral satellite imagery ground-truthed within the CDOM Observatory.

3.) Refine a predictive watershed model for CDOM sources based on a Soil Water Assessment Tool (SWAT) and Geographical Information Systems to predict sources of CDOM to the estuary.

4.) Refine the existing Boston Harbor physical/biogeochemical model to provide a 3-day forecast of CDOM distributions in Boston Harbor.

5.) Observe CDOM distributions and processes in the Neponset Watershed and Estuary and Boston Harbor for at least 12 months and refine observation protocols and predictive modeling capabilities.

6.) Develop "smart" network to respond to episodic events.

7.) Extend and deploy CDOM observatory in the Hudson Estuary for a 2-week period to show general applicability of the observation and prediction capabilities. This will hopefully be done in conjunction with Alan Blumberg at the Stevens Institute of Technology.

APPROACH

The CDOM Observatory is composed of five major components: continuous monitoring stations, targeted sampling, remote sensing, watershed and coastal modeling, and cyberinfrastructure. Initial focus for all monitoring, sampling, and remote sensing will be the Neponset Watershed, Neponset Estuary, and Boston Harbor, but occasionally, cruises will extend throughout Boston Harbor out into Massachusetts Bay to follow the fate of terrestrial CDOM into coastal ocean waters. Towards the end of Year 2, the CDOM Observatory will be redeployed in the Hudson Watershed and Estuary to determine the transferability of the Observatory.

Bernie Gardner and Francesco Peri will be responsible for development, deployment, and maintenance of the CDOM observatory—the continuous monitoring stations in the estuary and watershed, and integration of the AUV. Watershed modeling and remote sensing will be carried out by Yong Tian who has developed remote sensing algorithms for CDOM based on hyperspectral radiometric measurements in the Gulf of Mexico and Hudson Estuary. Estuarine/coastal modeling will be carried out by Mingshun Jiang who maintains a Boston Harbor/Massachusetts Bay predictive model. Francesco Peri will be responsible for cyberinfrastructure development.

WORK COMPLETED

Four low-cost (<$10k) buoys were designed, constructed and deployed in the Neponset Estuary/Boston Harbor area. CDOM, water temperature, and chlorophyll fluorescence, as well as current direction, wind speed and direction, barometric pressure, relative humidity, and PAR are being measured. Real-time data is available at:

Beacon 1(https://www.hobolink.com/p/67fad8cf59655d3831da0965ec94eb82)
Beacon 2 (https://www.hobolink.com/p/8070c5543ef4aeda6e6aa152360674a1)
Beacon 3 (https://www.hobolink.com/p/bf96553e35b2a5d650df09fd31a9000c)
Beacon 5 (https://www.hobolink.com/p/ff0eafa7216f343a20e27bd05963a0cd)

An AUV (YSI EcoMapper) has been identified and is being purchased. Autosampling units for watershed samples are also being obtained. 30 stations throughout the Neponset Watershed are sampled monthly and analyzed for dissolved organic carbon (DOC) and chromophoric dissolved organic matter (CDOM) in the form of fluorescence and absoprtion spectra. Monthly cruises up the Neponset Estuary have begun, and 10 discrete sampling locations have been determined. EO-1 satellite data has been scheduled (2 meter resolution and hyperspectral), but has so far only passed over on cloudy days. Our hyperspectral radiometer mounted on the bow of our research vessel has been useful in correlating the surface reflection with in situ CDOM measurements. The Boston Harbor model has been refined to increase the resolution to a 30 meter grid size in the Neponset Estuary portion of the Boston Harbor.

RESULTS

CDOM concentrations were observed to decrease over a monthly timescale in September. While tidal fluctuations and short term increases due to rain events are also evident, a decrease to about half of the fluorescence at several of the buoys suggest a source decrease. This is the first observation of CDOM endmember variability over these timescales that we are aware of. We are still checking to make sure this is not an artifact of biofouling or long term calibration drift due to some other influence.

The addition of high resolution (continuous) temporal CDOM measurements to our ability to observe 2-dimensional cross sectional CDOM with our Mini-Shuttle is changing the way that we think about CDOM export to coastal waters. Having a solid platform in the water will allow us to add new sensors to the buoy systems as well as conduct spatial surveys (Mini-Shuttle) and targeted surveys (AUV) within a framework of observations. The increase in resolution of the Boston Harbor model allows us to examine different source and degradation models, for example a source distributed across the salt marsh versus a point source at a tidal creek, a constant source or a pulsed source from the estuary, an episodic source from the river flowing along the surface vs. an episodic riverine source that enters the estuary mixed to all depths.

IMPACT/APPLICATIONS

The deployment of the 4 buoys represents a large step forward in getting the CDOM observatory operational. Data is being gathered. Episodic events will be detected if they occur. As with all new deployments, many lessons will be learned about maintenance, expansion, and analysis of this continuous data set. Companies and academic and governmental collaborators have begun to contact us to expand our network in a variety of ways (e.g. new sensors, new communication packages, new applications). In addition, the low-cost buoys may be of interest to scientists and managers that need real-time nearshore data on our coastal water quality.

RELATED PROJECTS

The Boston Environmental Area Coastal Observation Network (BEACON) project is supported by the Department of Energy. This project within the UMassBoston Center for Coastal Environmental Sensing Networks (CESN) is aimed to provide a testbed sensor network system for testing new sensors, for facilitation collaborations with industry, for learning about the opportunities and barriers to maintaining a nearshore coastal sensor network, and to allow new research opportunities. The BEACON project is integral to allowing the ONR project to focus on CDOM and episodic releases of CDOM.

NASA has recently funded a project on the "Geospatial Synthesis of Chromophoric Dissolved Organic Matter Distribution in the Gulf of Mexico for Water Clarity Decision Making" (Chris Osburn, PI; Eurico D'Sa, Paula Coble, Tom Bianchi, co-PIs). Data on CDOM export from terrestrial systems into the Gulf of Mexico and related remote sensing data will be useful to this ONR project's goal to better understand CDOM flow from terrestrial systems to marine systems and to use remote sensing to estimate in situ optical properties.

Another project supported by NSF-Chemical Oceanography entitled "DOC Outwelling from Salt Marshes" has been approved for funding. Robert Chen will act as PI along with Jennifer Cherrier (FAMU), Jaye Cable (LSU), and Christof Meile (UGA) as co-PIs. This focused study on DOC and CDOM produced in salt marshes will help refine our estuarine models of sources of CDOM to estuaries. Several of the buoy designs for our CDOM observatory may be used in this project, and alternatively, new buoy designs generated in the NSF project may be used in the ONR CDOM observatory.

PUBLICATIONS

Huang, W. and Chen, R.F., 2009. Sources and transformations of chromophoric dissolved organic matter (CDOM) in the Neponset River Watershed. JGR-Biogeosciences [in press, refereed].

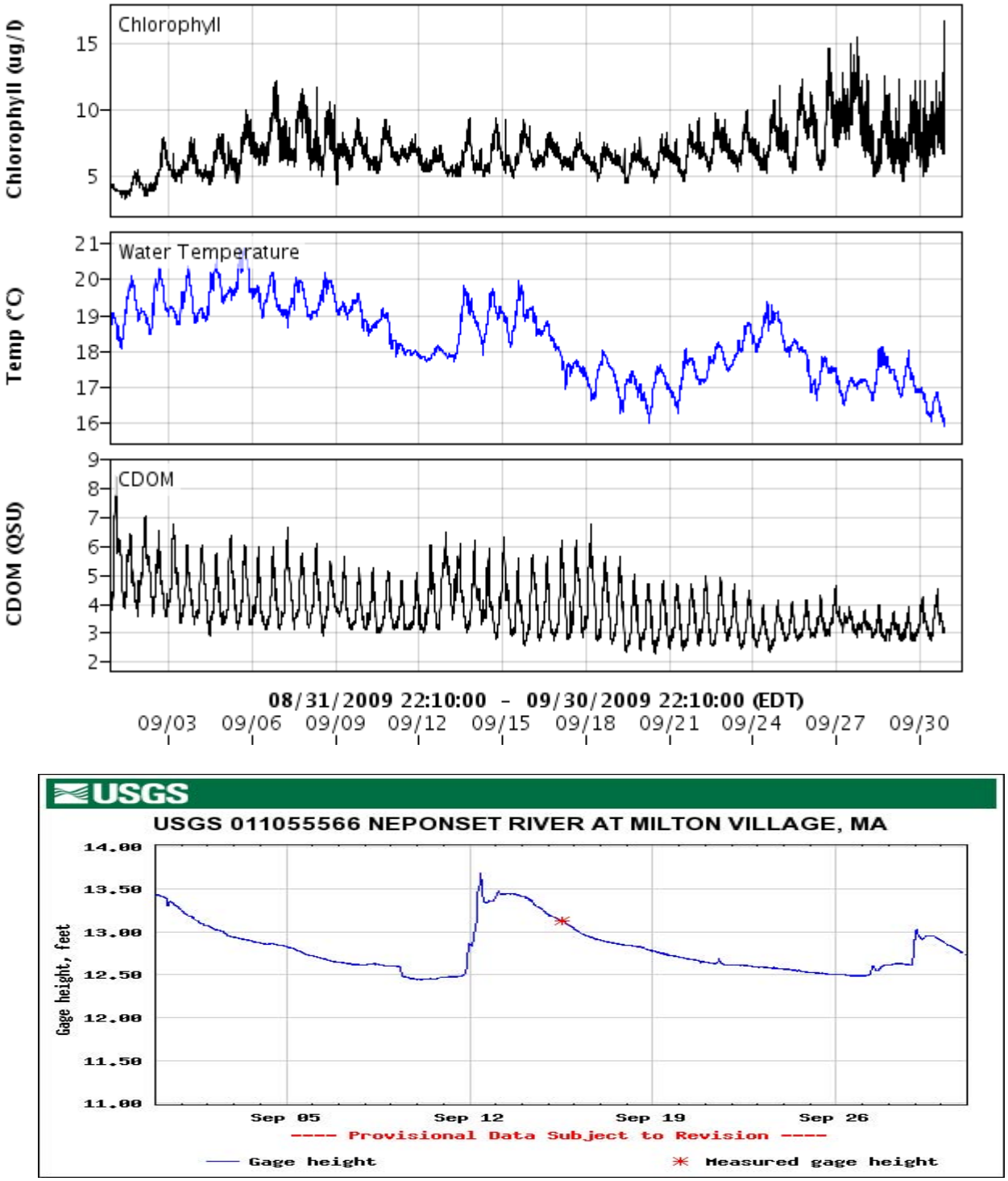

Figure 1: Chlorophyll fluorescence, water temperature, and CDOM fluorescence from Buoy 2 from the mouth of the Neponset River Estuary as well as stream gage height at the head of the Neponset Estuary during the month of September. Tidal fluctuations and the influence of a rain event on September 12th are seen, but a more general decrease in CDOM, decrease in temperature, and increase in chlorophyll is seen during this time period.